1965

DEPARTMENT OF AGRICULTURE AND FISHERIES

FOR SCOTLAND

LIBRARY
MAY 14 1965
FISH & WILDLIFE SERVICE

Marine Research
1965 No. 1

The Stocks of *Trisopterus esmarkii* (Nilsson) off North-west Scotland and in the North Sea

By D. F. S. RAITT, B.Sc.
Marine Laboratory, Aberdeen
July, 1964

EDINBURGH: HER MAJESTY'S STATIONERY OFFICE

PRICE 7*s*. 6*d*. NET

The following list shows the publications during recent years in the Marine Research series formerly issued by the Scottish Home Department. Details of earlier publications will be supplied on request by the Marine Laboratory, Department of Agriculture and Fisheries for Scotland, Victoria Road, Torry, Aberdeen.

MARINE RESEARCH SERIES

1961 1. Trawl Performance—A Study Relating Models to Commercial Trawls.
By W. Dickson, B.Sc. Price 18s. (18s. 5d.)

2. The Assessment of the Long Term Effects of Changes in Gear Selectivity and Fishing Effort.
By Rodney Jones, B.Sc. Price 10s. (10s. 4d.)

3. Scottish Oyster Investigations, 1946-1958.
By R. H. Millar, Ph.D., F.R.S.E. Price £1 2s. 6d. (£1 3s. 0d.)

4. The Oceanic and Bathypelagic Plankton of the North-East Atlantic and its possible significance to Fisheries.
By J. H. Fraser, D.Sc., Ph.D., F.R.S.E. Price 16s. (16s. 5d.)

5. The Histological Changes in the Gonad associated with the Reproductive Cycle of the Herring (*Clupea harengus* L.).
By A. B. Bowers, B.Sc. and F. G. T. Holliday, B.Sc. Price 9s. (9s. 5d.)

6. The Environment of a Herring Fishery.
By John H. Steele, B.Sc. Price 7s. 6d. (7s. 10d.)

1962 1. Herring Rearing IV—Rearing beyond the Yolk-Sac Stage.
By J. H. S. Blaxter, M.A. Price 6s. 6d. (6s. 10d.)

2. Haddock Bionomics II—The Growth of Haddock in the North Sea and at Faroe.
By Rodney Jones, B.Sc. Price 6s. 6d. (6s. 10d.)

3. The Food of the Norway Lobster—*Nephrops norvegicus* (*L.*).
By H. J. Thomas, B.Sc., Ph.D., and C. Davidson. Price 5s. (5s. 3d.)

4. Vitamin A and Fat in the Herring (*Clupea harengus* L.) and in its Food.
By L. R. Fisher, B.Sc., Ph.D. and Zena D. Hosking, B.A. Price 11s. (11s. 4d.)

1963 1. Undersea Photography in Marine Research.
By R. E. Craig, B.Sc., A.Inst.P., and R. Priestley. Price 15s. (15s. 4d.)

2. The Incidence of Larvae of *Porrocaecum decipiens* in the Flesh of Cod.
By Bennet B. Rae, M.A., B.Sc., Ph.D., F.R.S.E. Price 9s. (9s. 4d.)

3. The Food of the Megrim.
By Bennet B. Rae, M.A., B.Sc., Ph.D., F.R.S.E. Price 7s. 6d. (7s. 10d.)

4. The Scottish Whiting Fishery in the North Sea 1955-1960.
By Ray Gambell, B.Sc. Price 10s. 0d. (10s. 4d.)

5. Investigations of the Oyster Beds in Loch Ryan.
By R. H. Millar, Ph.D., F.R.S.E. Price 7s. 6d. (7s. 10d.)

1964 1. Plaice Investigations in Scottish Waters—I. Size-Composition of the Stocks, 1910-1952.
By J. M. Lamont. Price 9s. (9s. 6d.)

2. Vitamin A, Carotenoids and Total Lipids in the Livers of some Elasmobranchs.
By L. R. Fisher, B.Sc., Ph.D. Price 6s. (6s. 4d.)

(Prices in brackets include postage)

Obtainable from Her Majesty's Stationery Office
at the addresses on page 4 of cover or through any bookseller

DEPARTMENT OF AGRICULTURE AND FISHERIES
FOR SCOTLAND

MARINE RESEARCH
1965 No. 1

The Stocks of *Trisopterus esmarkii* (Nilsson) off North-west Scotland and in the North Sea

By D. F. S. RAITT, B.Sc.
Marine Laboratory, Aberdeen
July 1964

EDINBURGH: HER MAJESTY'S STATIONERY OFFICE
1965

CONTENTS

	Page
INTRODUCTION	5
MATERIAL AND METHODS	5
Larval distribution	5
Infection by *Myxobolus aeglefini* Auerbach	6
RESULTS	7
Distribution of Larval fish	7
Surveys in 1953	7
Surveys in 1954	7
Surveys in 1955	7
Surveys in 1956	7
Infection of *T. esmarkii* with *Myxobolus aeglefini*	9
DISCUSSION	9
SUMMARY	11
REFERENCES	12

The Stocks of *Trisopterus esmarkii* (Nilsson) off North-west Scotland and in the North Sea

INTRODUCTION

Early references to the Norway pout [*Trisopterus esmarkii* (Nilsson) formerly *Gadus esmarkii* Nilsson—for details of synonymy see Svetovidov, 1948] gave little idea of its abundance and were principally concerned with recording the occurrence of what, at that time, was taken to be a relatively uncommon species (e.g. Nilsson, 1855; Gunther, 1888; Holt & Calderwood, 1895; Petersen & Levinsen, 1900). Since it does not usually exceed 20 cm it was seldom caught in any numbers in commercial trawls. Fulton (1901a) first recorded large catches from Scottish waters when he wrote "judging from its numbers in the hauls made with the small-meshed net . . . it is probable that further investigations with suitable appliances will show it to be one of the most abundant Gadi in our seas".

Since 1920 large numbers of *T. esmarkii* have been regularly recorded during research surveys in the North Sea, on the west coast of Scotland and at Faroe, by Scottish research vessels. Until a few years ago this fish had not been exploited commercially and its biology had been little studied. However, with the recent interest in industrial fishing for species formerly considered to have no commercial value, many species such as *T. esmarkii*, sand-eels, etc., have become increasingly important.

Two recent reports (Mason, 1960; and quoted in Fraser, 1958) suggested that the North Sea stock of *T. esmarkii* could be derived to a considerable extent from spawnings to the north of the Hebrides and the north coast of Scotland (west of Orkney and Shetland) as well as from spawnings in the extreme northern North Sea. They suggested that in the early spring *T. esmarkii* from the North Sea might migrate to these grounds to spawn and the resulting larvae drift into the North Sea with the prevailing currents.

The possibility of *T. esmarkii* in Scottish waters being divisible into more or less distinct stocks in the North Sea and off the north-west coast has been investigated as part of a general bionomic study. The main sources of evidence in this investigation are the distribution and abundance of larvae during the post-spawning season, and the distribution and incidence of a protozoan parasite on the adult fish.

The objectives of the investigation are to determine whether the spawning products from the north and west Scottish coasts contribute substantially to the northern North Sea population and whether the adults in the northern North Sea and off the north and west coasts are distinct from one another.

MATERIAL AND METHODS

Larval Distribution

From 1952 to 1957 Saville (1959), in his work on the planktonic stages of haddock in Scottish waters, surveyed the northern North Sea, from 57°N to 61°N, from the Scottish east coast to the Norwegian coast, and the area off the north coast of Scotland, from the Butt of Lewis to Shetland within the 200 metres' depth contour.

Sampling was done by oblique hauls from the bottom to the surface with a 1 metre silk net, with 60 meshes to the inch (23·6 meshes to the cm), towed at a speed of 2 knots. In addition to the haddock eggs and larvae, most of the accompanying planktonic animals were also counted and the author has been able to make use of the data for *T. esmarkii* larvae from these surveys. All the catch data have been corrected to a standard tow of 15 minutes.

An oblique haul would seem to be the best method of catching the larvae of *T. esmarkii*. Henderson (1953) found none in 6 years of sampling the North Sea with the continuous plankton recorder, and concluded that they were not present at depths of 10 metres in sufficient numbers to be represented in

the catches. No distinction has been made in Saville's samples between the larvae of *T. esmarkii* and *T. minutus* (the poor cod) which were combined under one type heading, *"esmarkii/minutus"*. Schmidt (1909) and Damas (1909) have both commented on the difficulties in distinguishing between the larvae of these two species. Schmidt separated them by the rather laborious method of counting the vertebrae but Damas treated all the larvae of this type which he encountered in northern waters as *T. esmarkii*, since, he said, his samples were all collected in areas of known *T. esmarkii* larval abundance and at the northern limit of the range of *T. minutus*. *T. minutus* is a more southern species than *T. esmarkii*, occurring mainly in the shallower inshore waters of the southern North Sea and south and west British coasts. *T. esmarkii* does not occur there but is most abundant in the deeper waters (over 100 m) of the northern North Sea and north and west British coasts. Therefore, in the present investigation the *"esmarkii/minutus"* larvae from the surveys are assumed to have been almost if not entirely larvae of *T. esmarkii* only.

The numbers of *T. esmarkii* eggs in the samples were not counted separately but were included with those of several other species which they resemble very closely (all without an oil globule and measuring less than 1·2 mm in diameter), so that no data are available on actual egg production. However, for the purpose of determining whether spawning takes place separately in the North Sea and off the west coast, the larval data are considered adequate.

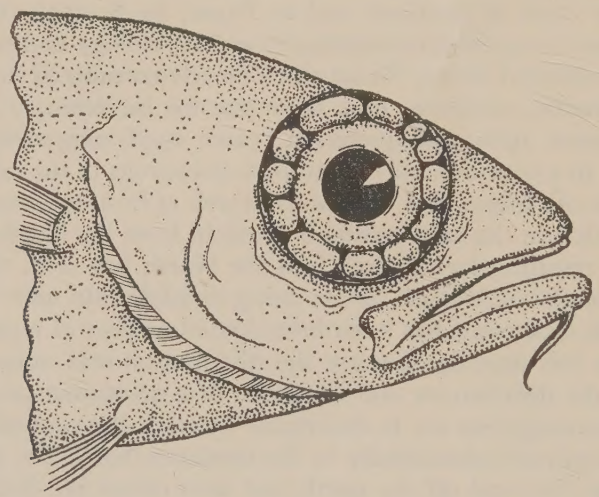

Fig. 1 External infection of the eye of *Trisopterus esmarkii* by *Myxobolus aeglefini*.

Infection by *Myxobolus aeglefini* Auerbach

The parasite is found in the cranial cartilage of several species of fish (Kabata, 1957). In severe infections, however, it frequently invades the scleral cartilage of the eye, and forms white cysts round the periphery of the cornea. These circular or elongated masses are often joined together like a string of beads and each is packed with cnidosporidian polar capsules. This external form of the infection (Fig. 1), was first noted on the eyes of *T. esmarkii* from the west coast of Scotland by Gunther (1888) and subsequently by Fulton (1901b) and Johnstone (1906). The presence or absence of these white cysts is easily noticed, and it gives a clear external indication of the severity of the infection. No published record so far exists of its occurrence in *T. esmarkii* from the North Sea.

The fish examined for this parasite were collected during routine trawling surveys in the North Sea and off the west coast of Scotland from 1960 to 1962. In all 20,734 fish were examined.

RESULTS

Distribution of Larval Fish

Several references to the spawning period of *T. esmarkii* occur in the literature (Fries *et al.*, 1892-95; McIntosh & Masterman, 1897; and Fulton, 1901b) but no precise information was available until Schmidt (1909) and Damas (1909) produced their comprehensive works on the distribution of larval gadoids in northern waters. Schmidt stated that the spawning in the North Sea and adjacent waters extended from February to March with a peak in March. Damas, working in the same area, found the larvae from March to July with a peak period in April and May. Although Damas's surveys were confined to the North Sea, Schmidt also found large numbers of *T. esmarkii* larvae off the north coast of Scotland and the Butt of Lewis, and in the south Minch and south of the Hebrides.

Table I shows the periods during which the samples examined in the present investigation were collected. Coverage of each area, both in time and space, is considered reasonably adequate for the purpose of the present investigation, and the cruises span the periods during which the larvae of T. *esmarkii* would be expected to be most abundant, i.e. from March to May. The distribution and abundance of larvae recorded in the plankton hauls are shown in Figures 2 to 11.

Surveys in 1953 (Figs. 2 and 3)

The distribution of larvae off the north coast of Scotland in March (Fig. 2) and in the northern North Sea in April and May (Fig. 3) shows two main areas of abundance, one on the north Scottish coast and off the Butt of Lewis, and another in the northern North Sea between Shetland and Norway, north of latitude 59°N. No data are available from the north coast in other months, and in the North Sea survey in June (not illustrated) only a few larvae were found spread over a very wide area.

Surveys in 1954 (Figs. 4, 5 and 6)

Both the North Sea and north coast areas were well sampled in 1954. The picture for March (Fig. 4) shows the same general features as 1953. Two distinct larval concentrations can be recognised, one off the Butt of Lewis and the other in the northern North Sea between Shetland and Norway. That these concentrations are effectively distinct is borne out by the data in Figure 5 for April, although numbers of larvae were caught to the west of the Shetland Isles within the 200 metre depth contour. One important difference between the North Sea data for 1954 and those for 1953, however, is that in 1954 a smaller concentration of larvae was located between latitudes 57° and 58°N, in the area of the Gut and Devil's Hole fishing grounds. This minor concentration is quite distinct from the main northerly concentration. In June (Fig. 6) only a few larvae were caught in the areas sampled.

Surveys in 1955 (Figs. 7, 8 and 9)

A wide grid of stations was sampled in March and April 1955, when larval concentrations were found in the same two areas (Fig. 7). Again a few larvae were caught west of Shetland but the two concentrations were quite distinct. No samples are available from the Scottish north coast for the period May-June, and in the North Sea (Fig. 8) the larvae were widely scattered over the whole area sampled. Numbers of larvae were again caught in the south-east corner of the grid. Although larvae were scarce by June (Fig. 9) a few were taken in both regions and in the southern part of the grid.

Surveys in 1956 (Figs. 10 and 11)

Concentrations similar to those of previous years can be seen in the data for March-April (Fig. 10), and the southerly concentration already noted in the North Sea is very prominent. Unfortunately no data are available from the area to the west of Shetland. In April-May (Fig. 11) the overall picture is the same, with the northern North Sea and north coast larval concentrations quite distinct. Only a small portion of the North Sea area was sampled in June (not shown) and the few larvae caught were widely scattered.

TABLE I

PERIODS DURING WHICH SAMPLES WERE COLLECTED AND CORRESPONDING TEXT FIGURES SHOWING DISTRIBUTION OF LARVAE

Year	Time of Sampling			
	North Coast	Text Fig.	North Sea	Text Fig.
1953	13th–19th March	2	3rd April–8th May	3
			11th–22nd June	—
1954	15th–30th March	4	14th March–1st April	4
	16th–27th April	5	14th April–5th May	5
	13th–18th June	6	15th June–7th July	6
1955	26th–30th March	7	10th March–7th April	7
			12th May–6th June	8
	6th–15th June	9	16th June–19th July	9
1956	2nd–16th April	10	27th March–17th April	10
	3rd–6th May	11	21st April–31st May	11
			5th–21st June	—

TABLE II

DISTRIBUTION OF SAMPLES ANALYSED FOR INFECTION WITH *Myxobolus aeglefini*

Time of sampling	No. of samples	Fish less than 1 year old			Fish 1 year and older			Total number examined
		Number examined	Number infected	% infected	Number examined	Number infected	% infected	
North Sea								
September 1960	31	732	–	0·0	1,614	–	0·0	2,346
January 1961 (Scalloway Deeps)	1	–	–	–	150	–	0·0	150
March 1961	12	678	–	0·0	425	–	0·0	1,103
March 1962	1 fish	–	–	–	1	1	100·0	1
Total North Sea	44	1,410	–	0·0	2,190	1	0·1	3,600
West Coast								
November 1960	13	348	–	0·0	434	75	17·3	782
March 1961	19	5,676	–	0·0	1,403	148	10·5	7,079
November 1961	10	167	1	0·6	945	258	27·3	1,112
March 1962	8	174	4	2·3	962	116	12·1	1,136
July 1962	41	None examined			6,813	1,635	24·0	6,813
August 1962	4	None examined			212	36	17·0	212
Total West Coast	95	6,365	5	0·1	10,769	2,268	21·1	17,134

INFECTION OF *T. esmarkii* WITH *Myxobolus aeglefini*

Of 3,449 fish examined from two trawling surveys covering the whole northern North Sea area in September 1960 and March 1961, none had white patches on the surface of the eyeball and iris. Since these surveys a close watch has been kept for any infected fish from the North Sea and only one has been noticed, in a sample from the east coast of the Shetlands. It is clear that there is no significant evidence of external infection of the eye in juvenile or adult fish from the northern North Sea. In one sample from the Scalloway Deeps off the west coast of Shetland none of 150 fish examined showed any external signs of infection.

The examination of 17,134 fish from six trawling surveys off the west coast of Scotland (Table II) shows that, on average, 21·1% of the adult fish in the samples were infected. In fact the presence of the white eye patches was almost completely confined to the adult fish over 1 year of age (or about 14 cm in length and over). Only 5 of 6,365 juvenile fish examined were infected. It may well be that in the younger fish the infection, when present, had not had time to become severe enough to spread to the external surface of the eyes. The percentage of infected adults varied between cruises from 10 to 27%. The numbers of fish examined and infected in each statistical square (map reference) during the surveys are shown in Table III. Treated in this way the data show considerable differences between areas but very little difference between months for the same area. The statistical squares with the highest percentage infection were in the South Minch [XX13=77·8%] and in the Firth of Clyde [ZZ10=89·3%]. Figure 12 reveals two main centres of infection: (a) in the North and South Minch (average about 40%), (b) in the Firth of Clyde and adjacent waters (average about 70%). In the deeper water to the north, west and south-west of the Hebrides the percentage occurrence was less than 10% but was higher towards the Irish Sea.

DISCUSSION

The overall impression from the larval fish surveys is of two main centres of larval abundance, one off the north coast of Scotland and the other in the North Sea between Shetland and Norway. Indeed, apart from the charts for April-May 1953 (Fig. 3), May-June 1955 (Fig. 8) and April-May 1956 (Fig. 11), which could be interpreted as suggesting a slight larval drift through the Orkney-Shetland passage, the two areas are quite distinct. This result is similar to that obtained by Saville (1959) in his assessments of catches of haddock eggs and larvae from the same cruises, although *T. esmarkii* larvae in the North Sea tended to occur further north than those of haddock.

Although samples were not always available from the west of Shetland area, lying between the two main larval concentrations, there is no evidence in the data of a significant drift of larvae from the Butt of Lewis to the northern North Sea via the north of Shetland. Larvae resulting from spawnings to the west of Shetland, however, might well drift in this direction but the material available suggests that large numbers of larvae are not usually found in this region. Indeed the fact that the few larvae caught in June (Figs. 6 and 9) were in the same general areas as those caught in March, April and May suggests that larval drift may not be a very significant factor in determining the subsequent larval distribution.

Measurements of larvae from plankton hauls off the Butt of Lewis and east of Shetland in 1954 and 1955 (Table IV) show that at the same time (end of March-beginning of April), in both years, larvae from both areas were of approximately the same size. They had probably not had time to drift far from the area of spawning. Similar measurements made on 3 samples of larvae from the smaller, more southerly, secondary spawning in March and April 1956 indicate that they were of the same size range and probably arose from an independent spawning south of the main northern North Sea spawning.

In more recent years maturity studies have been made on adult *T. esmarkii* during routine trawling surveys in the northern North Sea. The distribution of ripe and ripe-running fish in March 1961 is shown in Figure 13. Spawning fish were distributed over a large part of the area investigated and in much the same region as the larval concentrations were found.

There can be no doubt that there is a substantial spawning in the northern North Sea, and from larval distribution and size data and the incidence of ripe-running adult fish it would appear to be quite independent of the spawning off the Butt of Lewis.

TABLE III

DISTRIBUTION OF INFECTED FISH ON WESTERN GROUNDS (BY STATISTICAL SQUARES)

Stat. Square	November 1960		March 1961		November 1961		March 1962		July 1962		August 1962		Total		
	No. examined	No. infected	No. examined	No. infected	No. examined	No. infected	No. examined	No. infected	No. examined	No. infected	No. examined	No. infected	No. examined	No. infected	% infected
VV 10	149	1	386	24	201	0	—	—	—	—	—	—	736	25	3·4
11	19	0	—	—	—	—	44	3	—	—	—	—	63	3	4·8
12	—	—	—	—	—	—	202	2	—	—	—	—	202	2	1·0
14	6	0	—	—	—	—	210	1	—	—	—	—	216	1	0·5
WW 10	—	—	—	—	—	—	—	—	—	—	51	3	51	3	5·9
11	27	6	76	7	214	9	34	4	—	—	—	—	351	26	7·4
12	147	29	—	—	221	72	—	—	—	—	53	10	421	111	26·4
15	—	—	—	—	—	—	84	6	—	—	—	—	84	6	7·1
XX 10	—	—	11	0	—	—	—	—	—	—	—	—	11	0	0·0
11	—	—	2	2	—	—	—	—	1,347	297	—	—	1,349	299	22·2
12	22	8	—	—	93	51	—	—	—	—	—	—	115	59	51·3
13	—	—	1	1	17	13	—	—	—	—	—	—	18	14	77·8
14	—	—	—	—	23	22	—	—	324	113	—	—	347	135	38·9
15	—	—	252	70	50	32	188	37	505	115	—	—	995	254	25·5
16	—	—	1	0	—	—	—	—	—	—	—	—	1	0	0·0
17	—	—	546	0	—	—	—	—	—	—	58	15	604	15	2·5
YY 8	—	—	—	—	71	26	—	—	—	—	—	—	71	26	36·6
9	—	—	21	5	5	5	—	—	208	81	—	—	234	91	38·9
10	—	—	—	—	—	—	—	—	35	18	—	—	35	18	51·4
11	—	—	—	—	—	—	—	—	5	2	—	—	5	2	40·0
14	—	—	—	—	—	—	—	—	613	208	—	—	613	208	33·9
15	64	31	77	15	50	28	200	63	3,732	778	50	8	4,173	923	22·1
ZZ 9	—	—	5	0	—	—	—	—	41	22	—	—	46	22	47·8
10	—	—	25	24	—	—	—	—	3	1	—	—	28	25	89·3
C 19	—	—	—	—	—	—	—	—	—	—	—	—	150	0	0·0
Total	434	75	1,403	148	945	258	962	116	6,813	1,635	212	36	10,769	2,268	21·1

TABLE IV

MEASUREMENTS OF LARVAE FROM NORTH COAST AND NORTH SEA SAMPLES, 1954-56

Serial number of sample	Position of sampling	Date	North Coast Larvae		North Sea Larvae		Number of larvae measured
			Mean length (mm)	Range (mm)	Mean length (mm)	Range (mm)	
1954							
C54/41	58°46'N 06°00'W	24.3.54	5·10	4–8			50
C54/43	58°46'N 06°30'W	24.3.54	4·57	3–8			49
C54/49	58°30'N 05°30'W	26.3.54	5·56	3–8			54
S54/222	61°01'N 00°30'W	25.3.54			3·64	3–6	64
S54/249	60°31'N 02°00'E	27.3.54			3·75	3–5	20
S54/251	60°31'N 01°20'E	27.3.54			4·02	3–6	65
1955							
S55/38	58°46'N 07°00'W	26.3.55	5·17	3–8			23
S55/118	61°01'N 01°00'E	3.4.55			4·25	3–6	48
S55/120	61°01'N 01°30'E	3.4.55			4·03	3–6	58
1956							
C56/47	57°30'N 02°00'E	29.3.56			4·60	3–8	57
C56/58	57°00'N 00°30'E	4.4.56			5·68	4–8	38
S56/250	57°00'N 01°00'E	16.4.56			5·91	4–9	56

The conditions which must be fulfilled in using parasites as biological indicators have been enumerated by Kabata (1963). It appears that the protozoan parasite *Myxobolus aeglefini* in *T. esmarkii* fulfils all these conditions in the present investigation and has been shown to occur as white patches in the corneal tissue of adult fish from the west and north-west coasts of Scotland but not on fish from west of Shetland and the northern North Sea. It seems logical to assume either that the North Sea fish are immune to the parasite or that there is no interchange of fish between the two areas after infection occurs. In either circumstance or both the distribution of the infection provides proof of the distinctness of the stocks from the two areas.

SUMMARY

The larvae of *T. esmarkii* are distributed over a very large area of the northern North Sea, between Shetland and Norway, in March and April each year. Length measurements suggest that they have not drifted far from the spawning area. Another centre of larval abundance occurs, at the same time of the year, off the north coast of Scotland and the Butt of Lewis. In the years investigated there was no significant evidence of a drift of larvae from this spawning round the north of Shetland into the North Sea. In certain years there is some evidence of a slight drift of larvae through the Orkney-Shetland passage.

White patches on the eye of adult fish, caused by severe infection with *Myxobolus aeglefini*, occur on fish from the west and north-west Scottish coasts but not on fish from the northern North Sea and west of Shetland.

These results support the hypothesis that the population of *T. esmarkii* in the northern North Sea arises mainly from spawnings within the North Sea area and there is no evidence to support the view that significant numbers of adult fish migrate in either direction between the two areas.

REFERENCES

Damas, D. 1909. Contribution à la biologie des gadides. *Rapp. Cons. Explor. Mer,* **10** (3), 1-277.

Fraser, J. H. 1958. The drift of the planktonic stages of fish in the north-east Atlantic and its possible significance to the stocks of commercial fish. *Spec. Publ. int. Comm. Northw. Atlant. Fish.,* **1,** 289-310.

Fries, B., Ekström, C. U. *and* Sundevall, C. 1892-95. A history of Scandinavian Fishes. 2nd ed. rev. by F. A. Smitt. 2 vols. in 3. Stockholm and London, Norstedt. pp. 1240.

Fulton, T. W. 1901a. Ichthyological notes, *Rep. Fish. Bd Scot.,* **19** (1900), 282.

—— 1901b On the rate of growth of the cod, haddock, whiting and Norway pout. *Rep. Fish. Bd Scot.,* **19** (1900), 154-228.

Gunther, A. 1888. Report on the fishes obtained by Mr J. Murray in deep water on the north-west coast of Scotland between April 1887 and March 1888. *Proc. roy. Soc. Edinb.* (B), **15,** 205-220.

Henderson, G. T. D. 1953. Continuous plankton records: The young fish and fish eggs, 1932-39 and 1946-49. *Bull. mar. Ecol.,* **3** (24), 215-252.

Holt, E. W. L. *and* Calderwood, W. L. 1895. Survey of fishing grounds, west coast of Ireland 1890-1891. Report on the rarer fishes. *Sci. Trans. R. Dublin Soc.,* ser. 2, **5,** 360-525.

Johnstone, J. 1906. On a myxosporidian infection of *Gadus esmarkii* (with a note on identification of the parasite by H. M. Woodcock). *Rep. Lancs. Sea-Fish. Labs,* **15,** 204.

Kabata, Z. 1957. Note on a new host of *Myxobolus aeglefini. Parasitology,* **47,** 165-168.

—— 1963. Parasites as biological tags. *Spec. Publ. int. Comm. Northw. Atlant. Fish.,* **4,** 31-37.

Mason, J. 1960. A report on the distribution of *Gadus esmarkii* Nilsson in the North Sea and adjacent waters. *I.C.E.S., C.M.* 1960, *Gadoid Comm.,* Doc. No. 41, pp. 4.

McIntosh, W. C. *and* Masterman, A. T. 1897. The life histories of the British marine food fishes. London, Clay. pp. 516.

Nilsson, S. 1855. Scandinavisk Fauna. Fjerde Delen, Fiskarna. Lund. pp. 768.

Petersen, C. G. J. *and* Levinsen, J. C. L. 1900. Trawlings in the Skager Rack and the northern Cattegat in 1897-98. *Rep. Danish biol. Sta.* (1899), **9,** 1-63.

Saville, A. 1959. The planktonic stages of the haddock in Scottish waters. *Mar. Res. Scot.,* 1959, No. 3, pp. 23.

Schmidt, J. 1909. The distribution of the pelagic fry and the spawning regions of the gadoids in the North Atlantic from Iceland to Spain. *Rapp. Cons. Explor. Mer,* **10** (4), 1-229.

Svetovidov, A. M. 1948. Fauna of U.S.S.R. Fishes. **9** (4), Gadiformes. [Trans. from Russian] (*Zool. Inst. Akad. Nauk,* n.s. no. 34). Jerusalem, 1962. pp. 304.

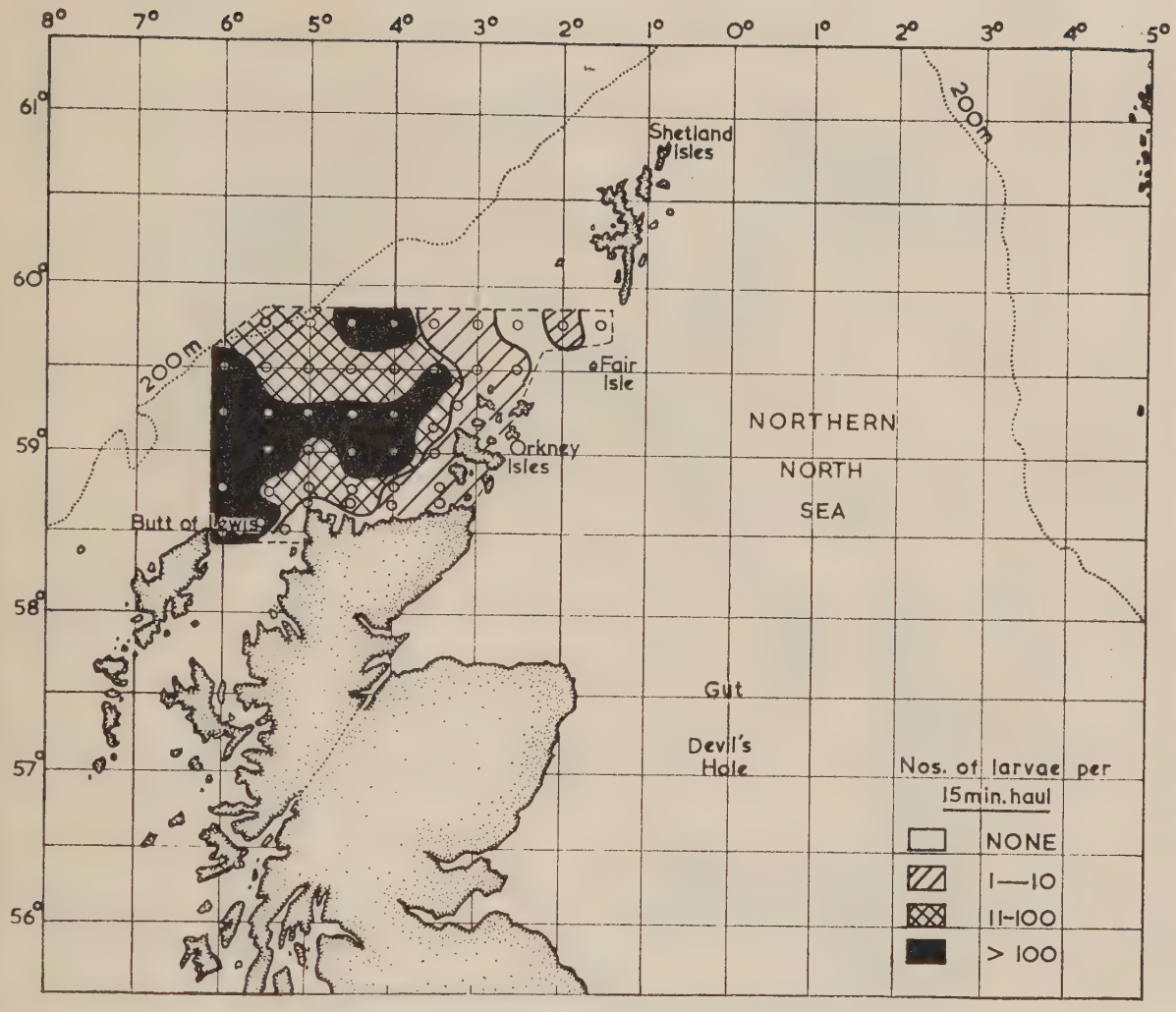

Fig. 2 Distribution of *Trisopterus esmarkii* larvae, March 1953.

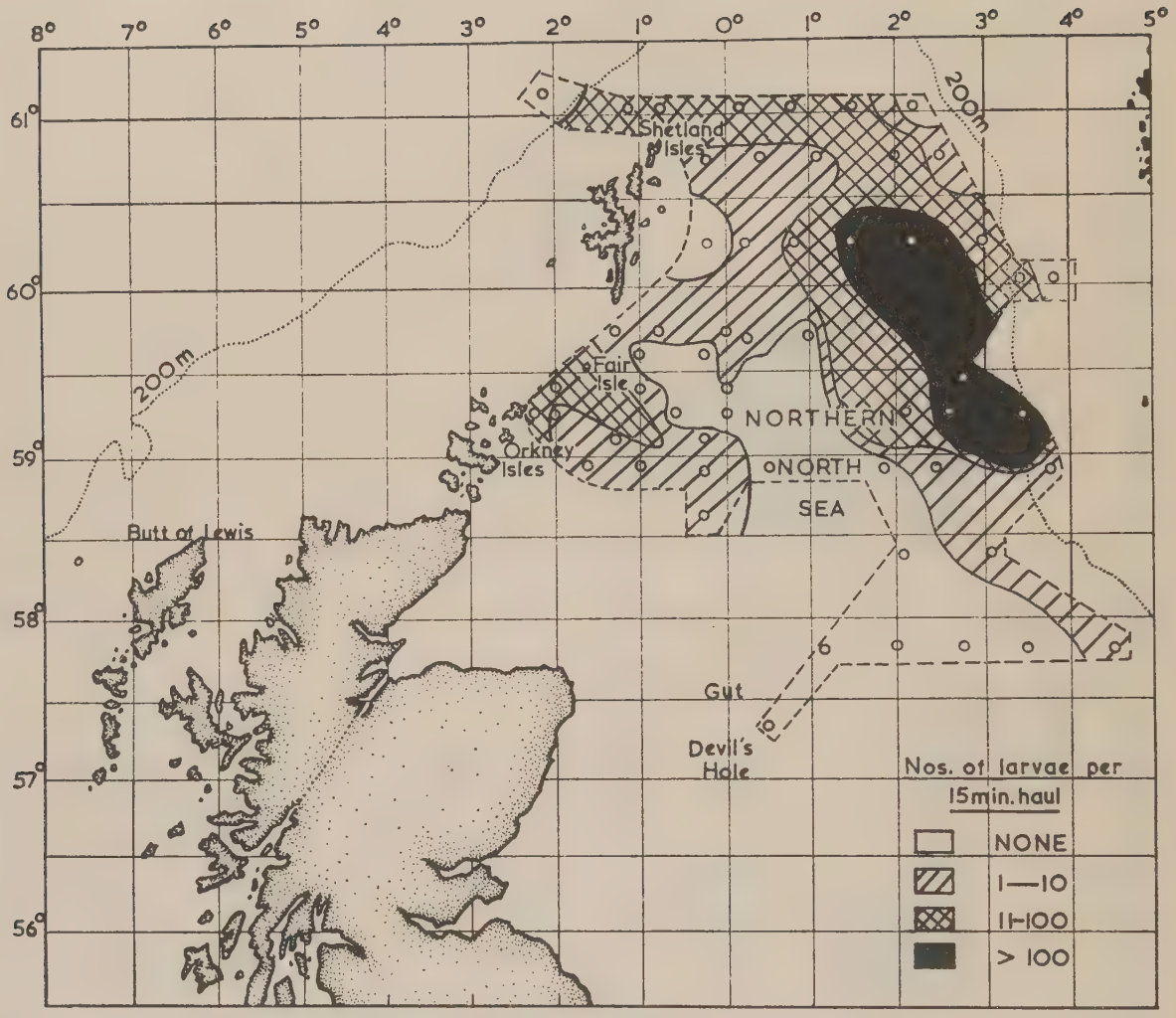

Fig. 3 Distribution of *Trisopterus esmarkii* larvae, April-May 1953.

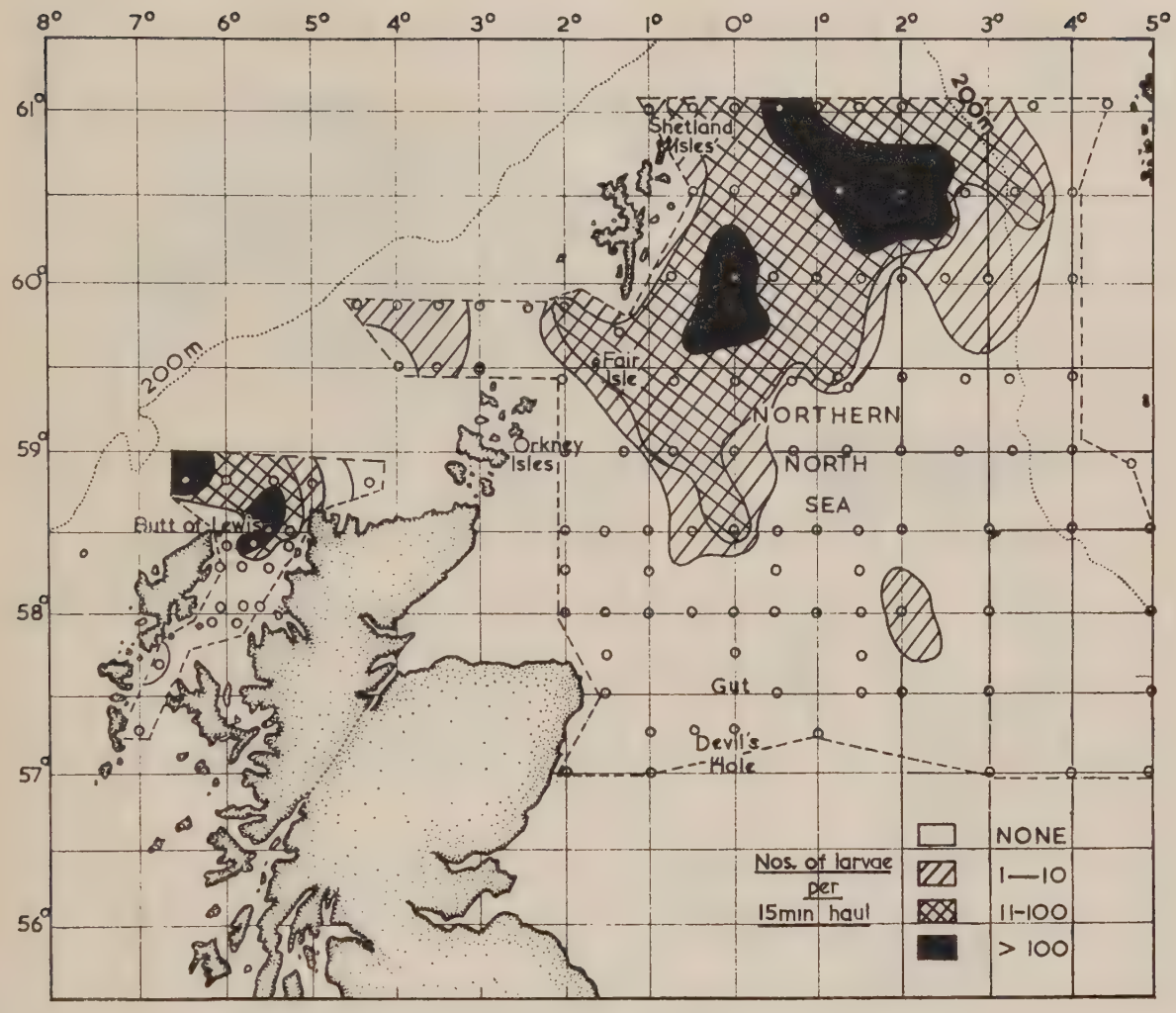

Fig. 4 Distribution of *Trisopterus esmarkii* larvae, March 1954.

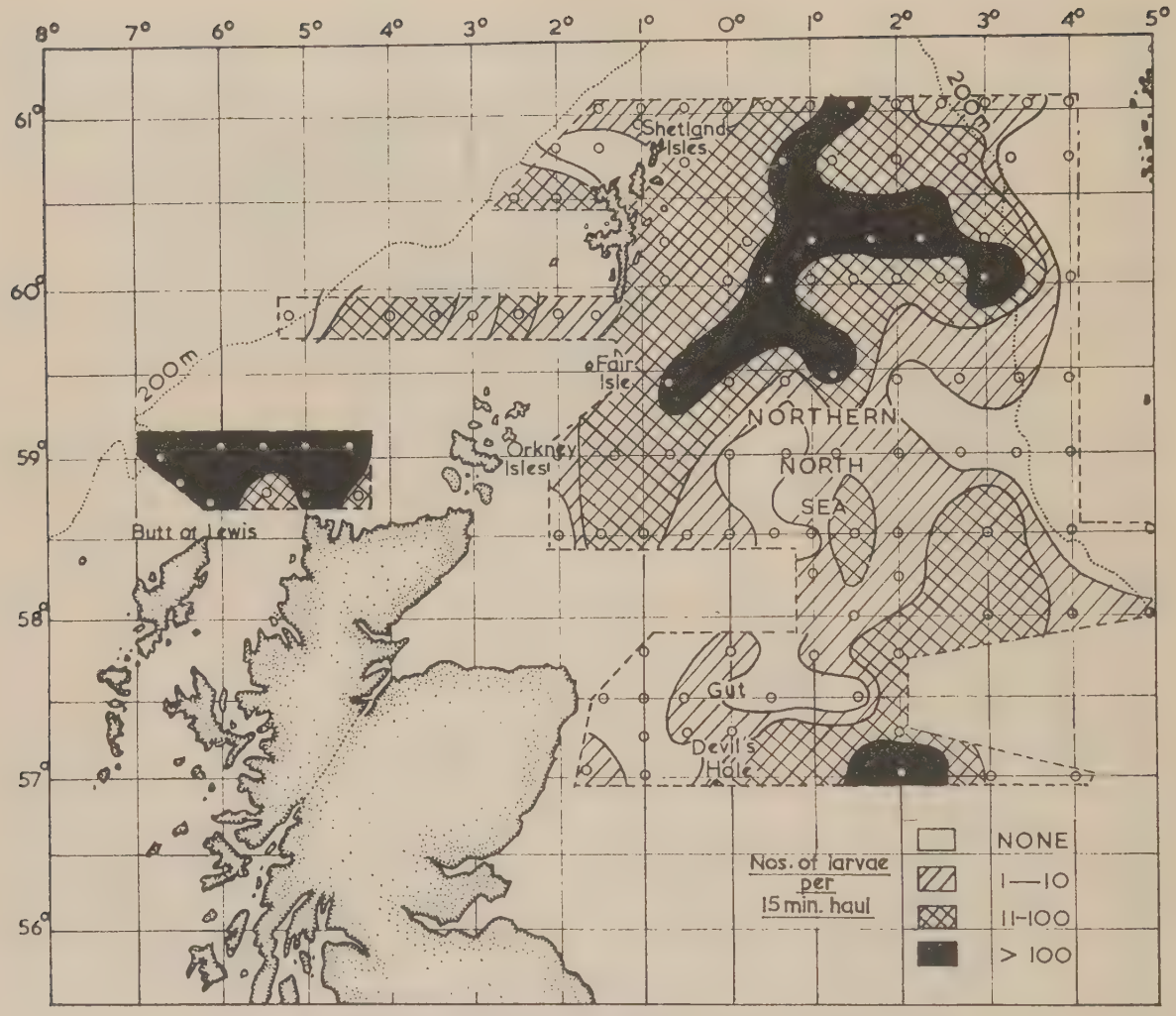

Fig. 5 Distribution of *Trisopterus esmarkii* larvae, April-May 1954.

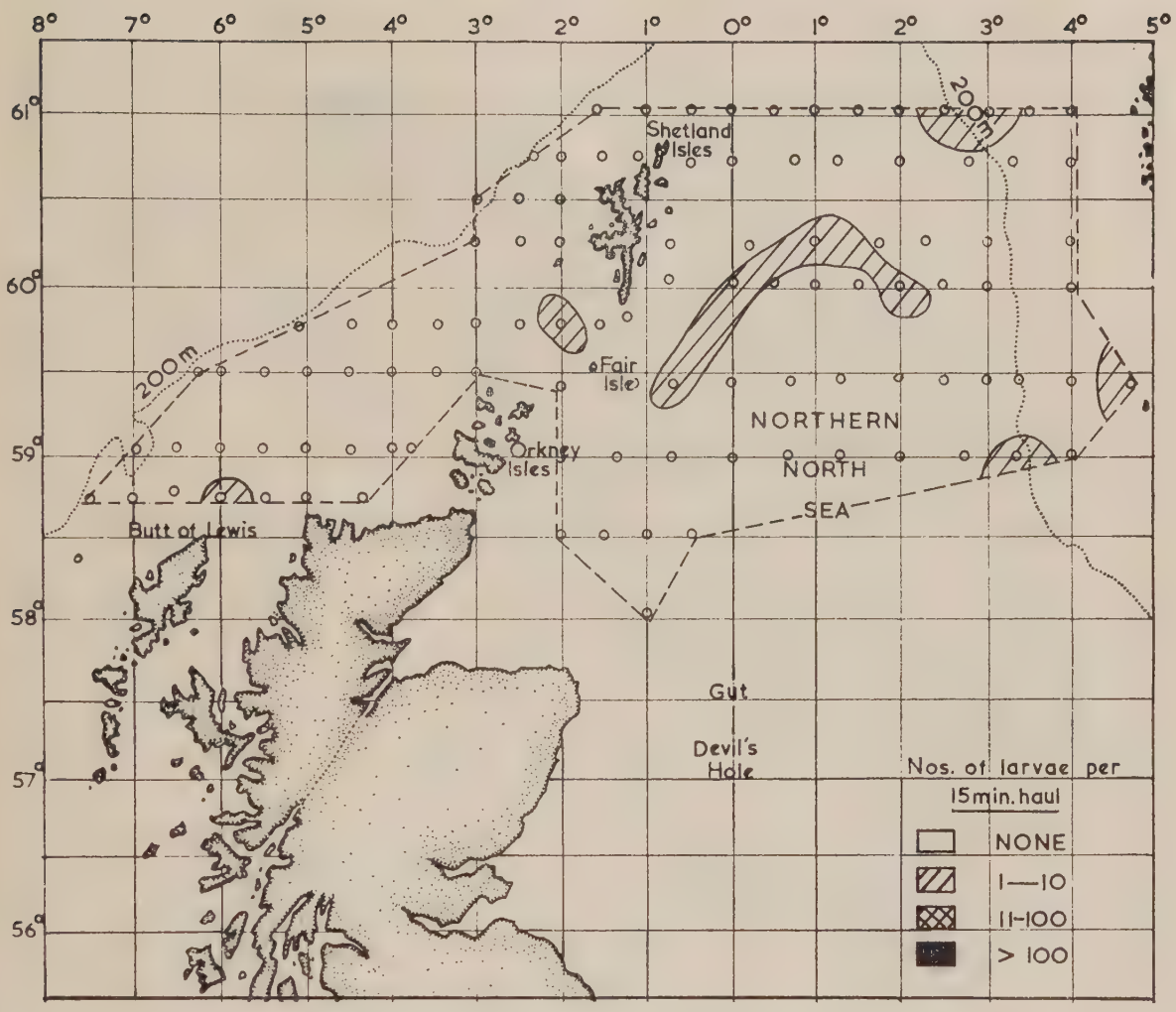

Fig. 6 Distribution of *Trisopterus esmarkii* larvae, June-July 1954.

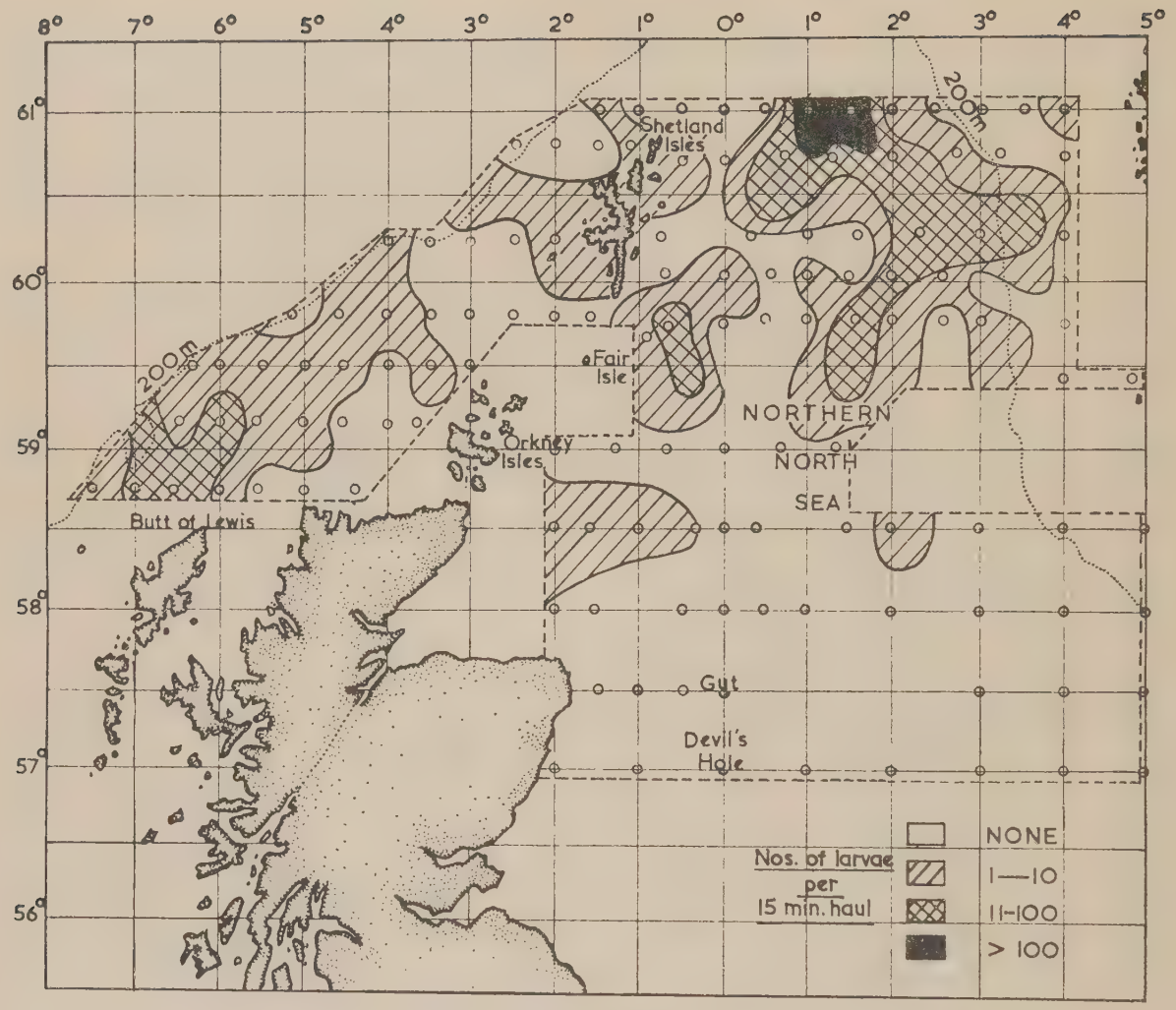

Fig. 7 Distribution of *Trisopterus esmarkii* larvae, March-April 1955.

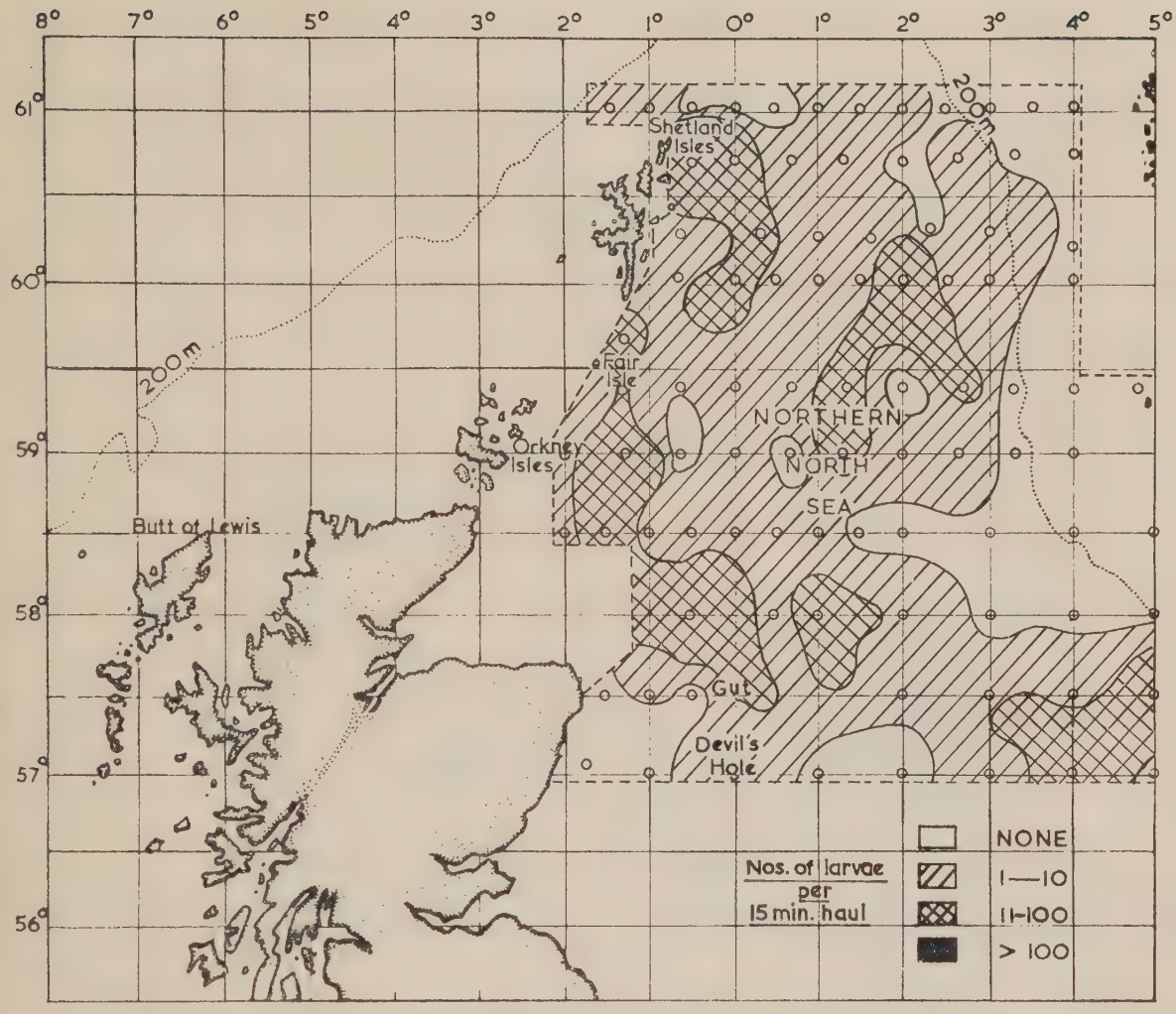

Fig. 8 Distribution of *Trisopterus esmarkii* larvae, May-June 1955.

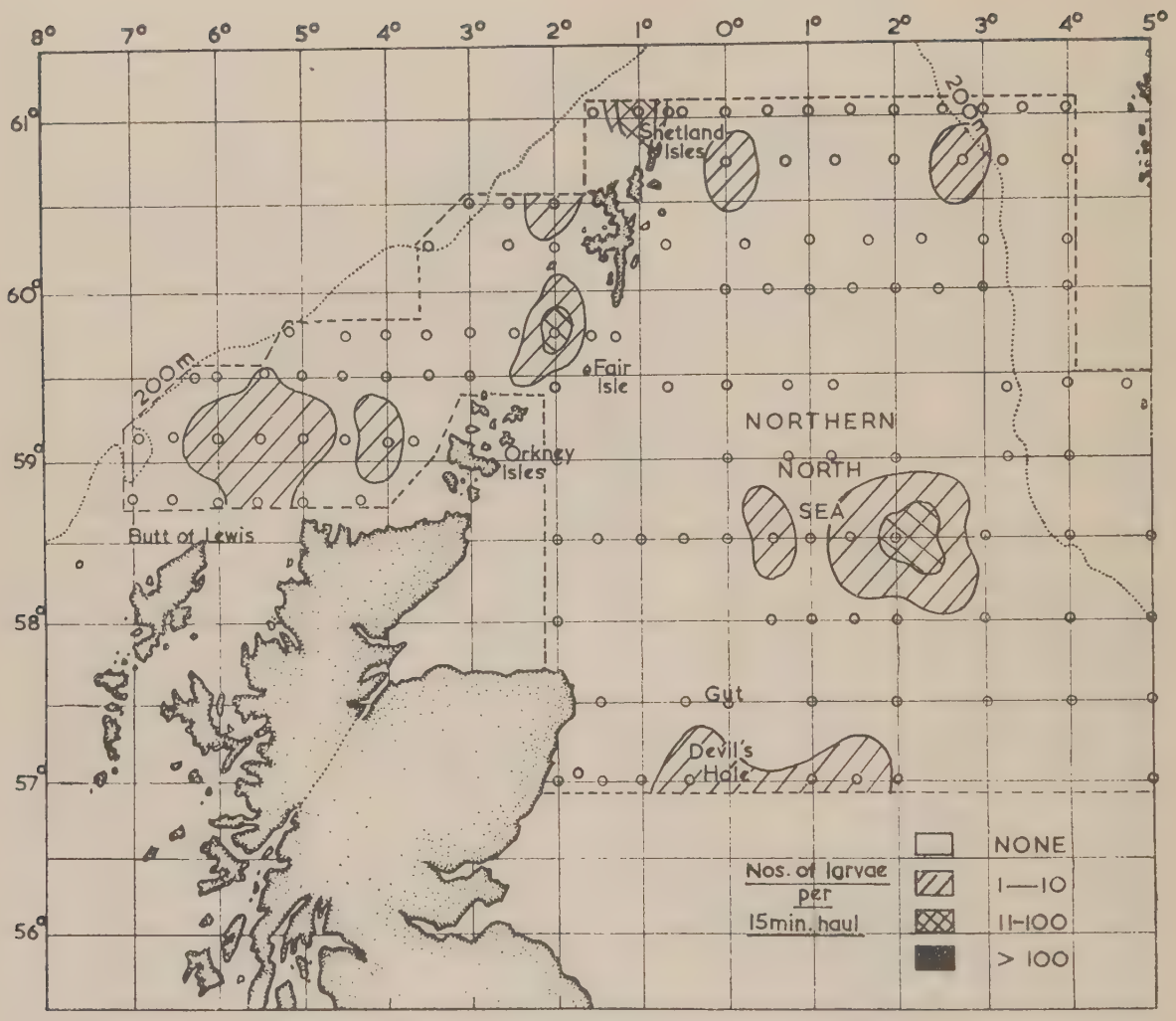

Fig. 9 Distribution of *Trisopterus esmarkii* larvae, June-July 1955.

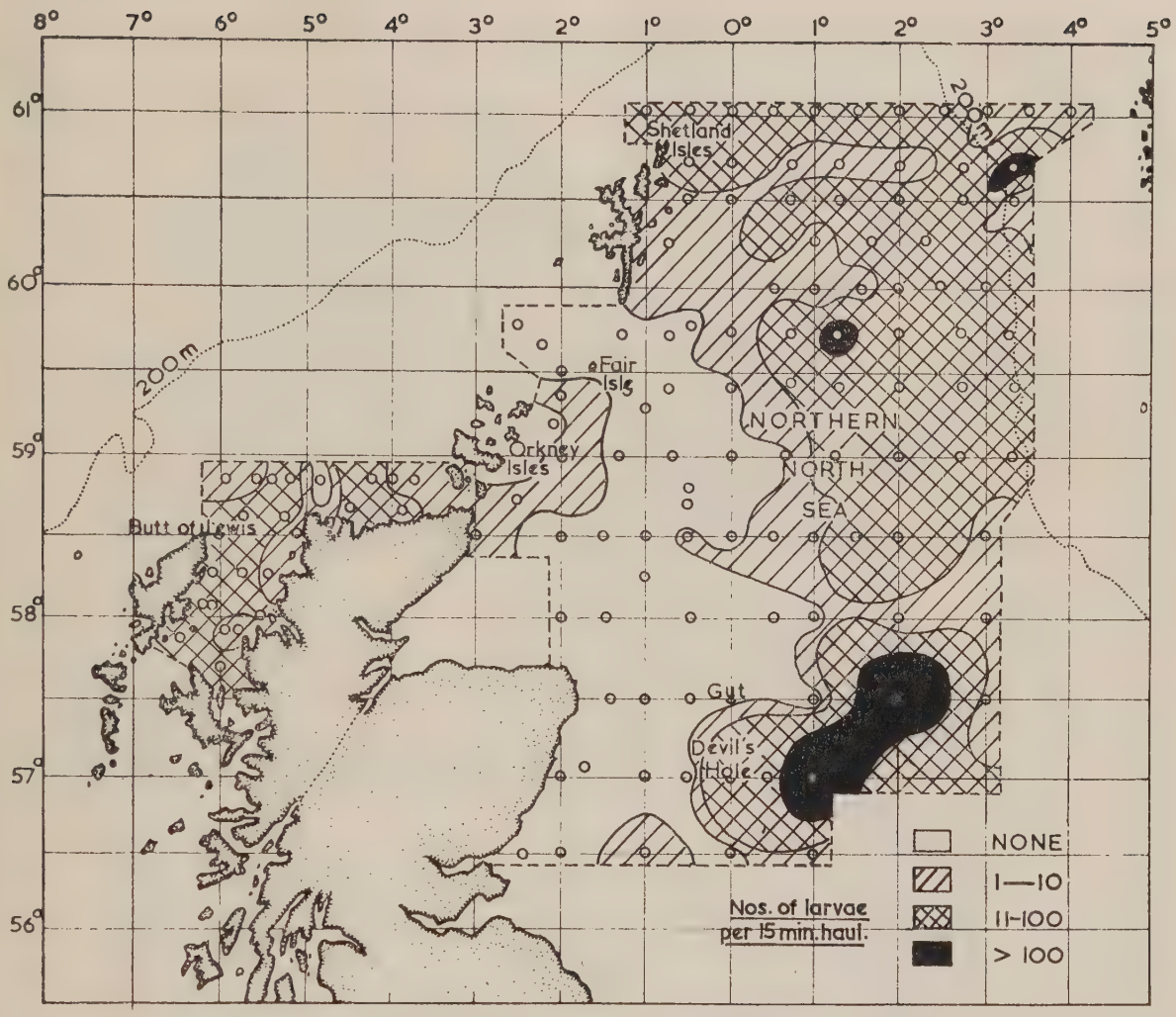

Fig. 10 Distribution of *Trisopterus esmarkii* larvae, April 1956.

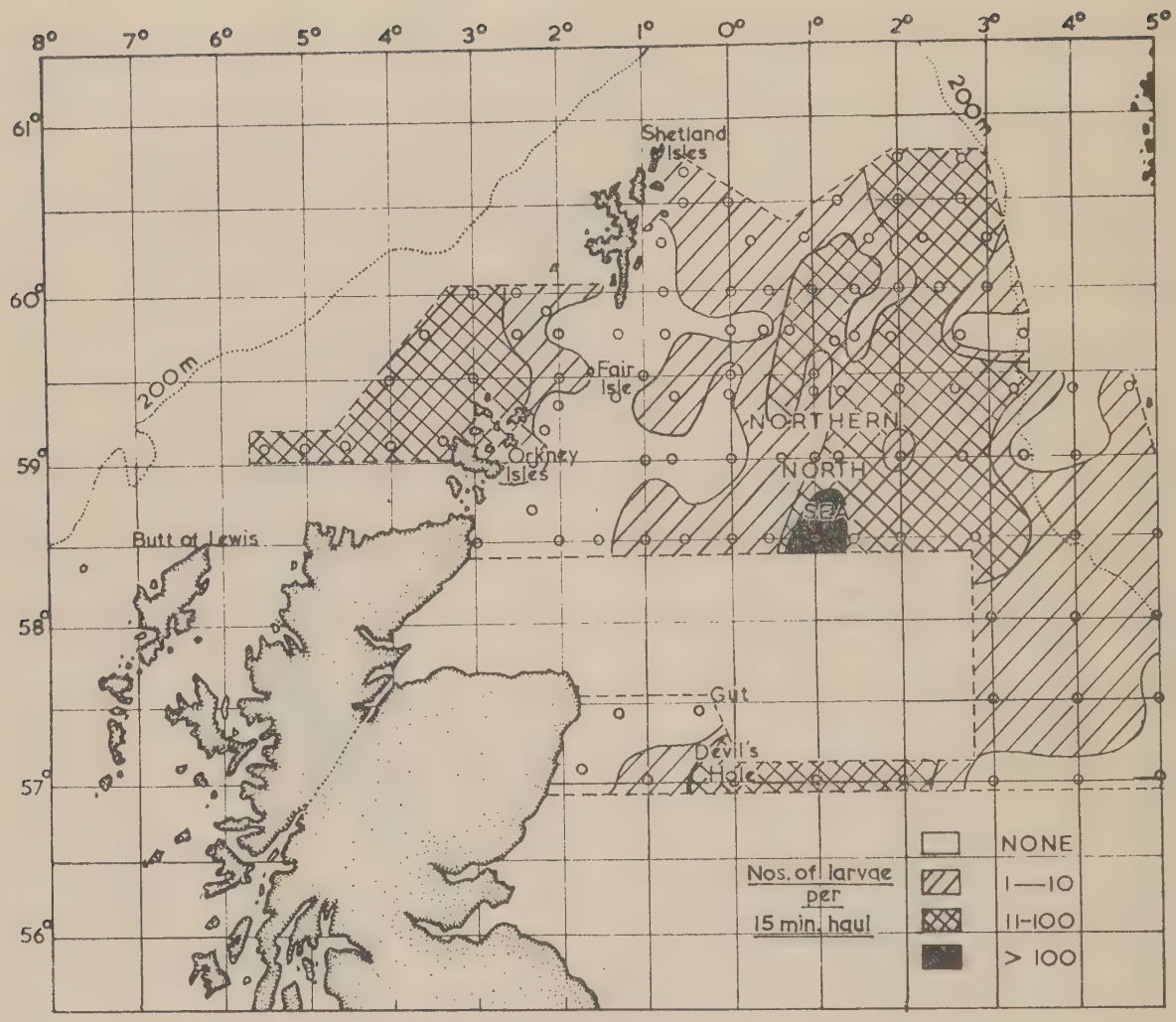

Fig. 11 Distribution of *Trisopterus esmarkii* larvae, April-May 1956.

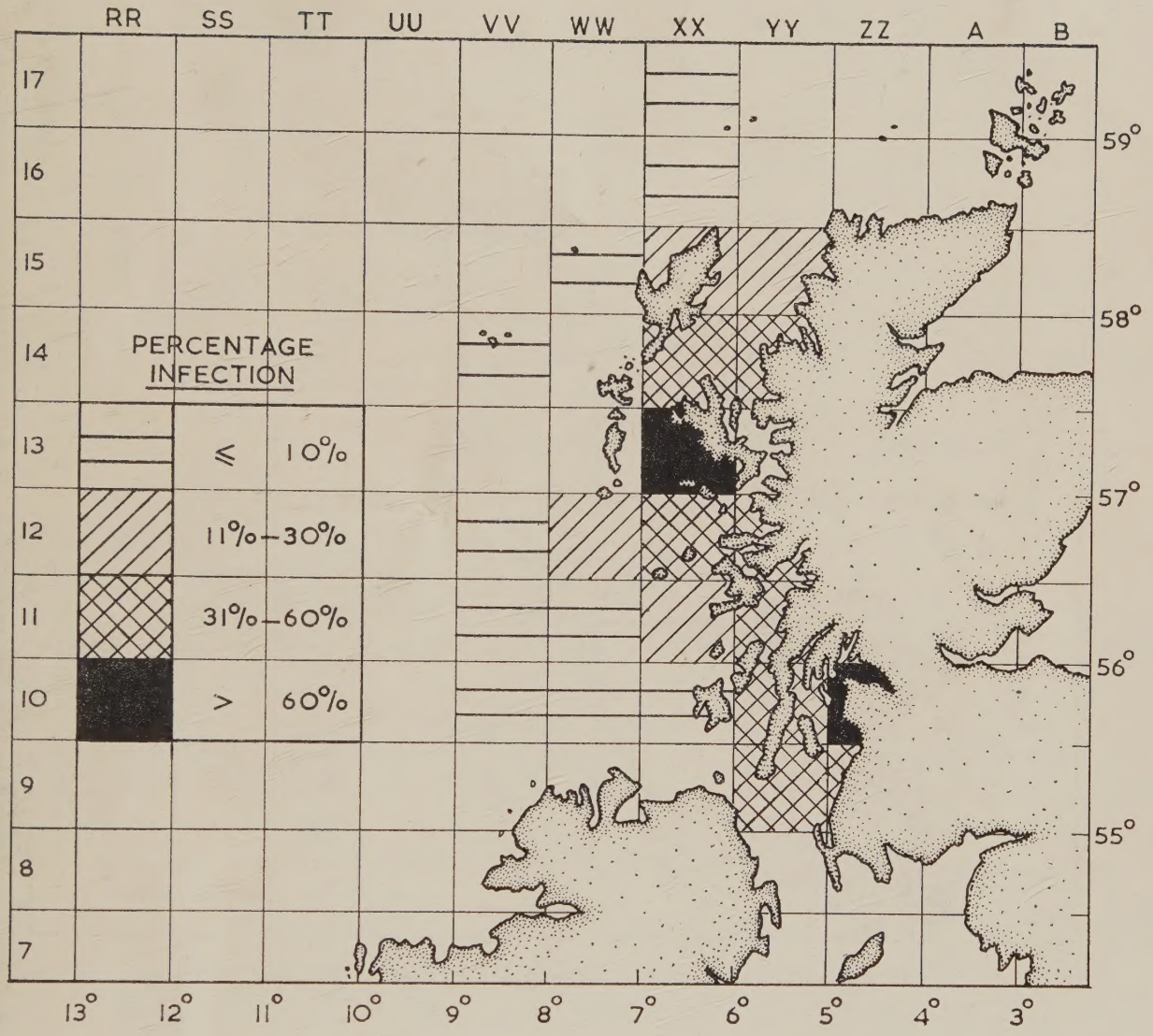

Fig. 12 Percentage of adult *Trisopterus esmarkii* infected with *Myxobolus aeglefini*.

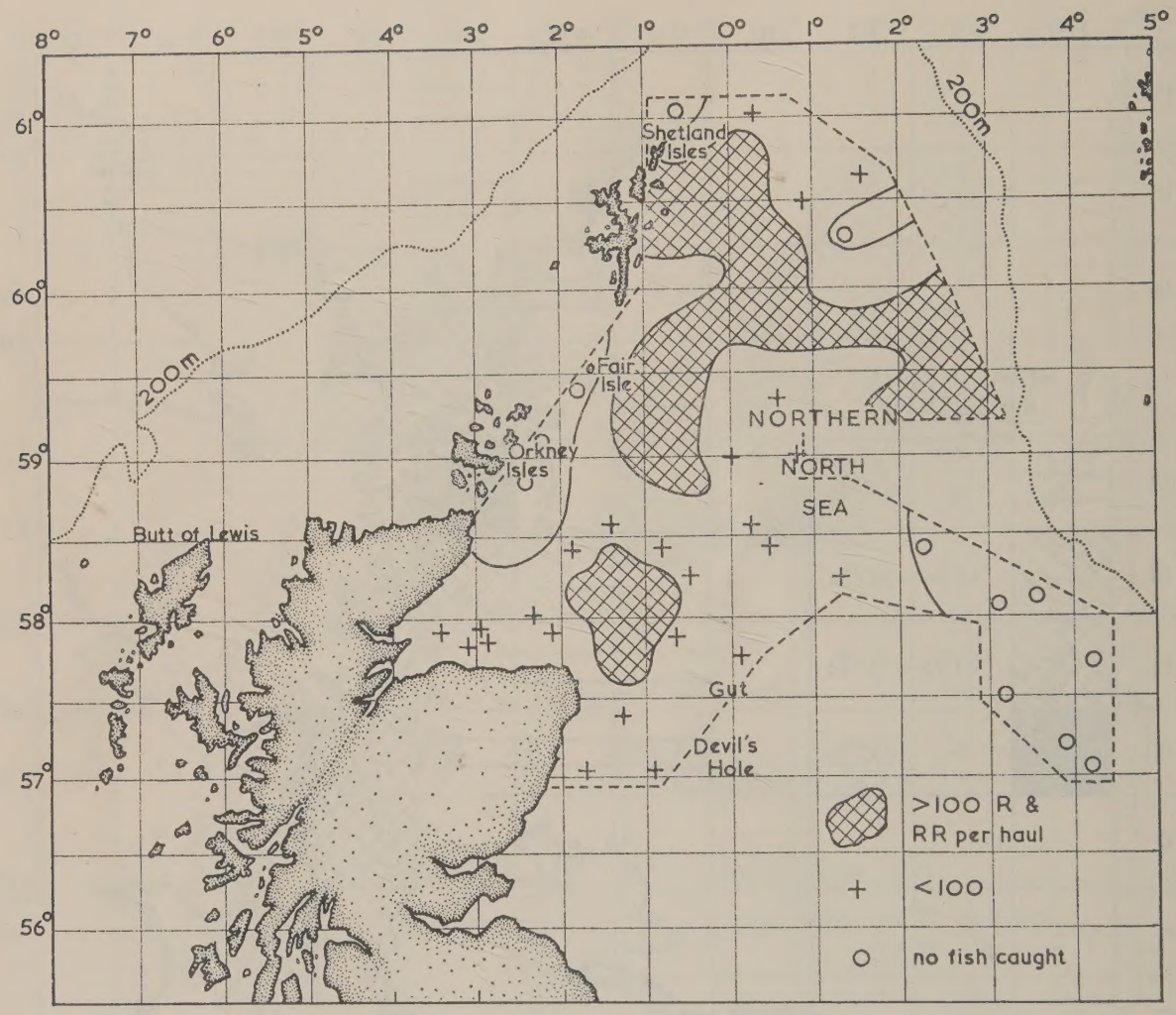

Fig. 13 Distribution of ripe and ripe-running adult *Trisopterus esmarkii*, March 1961.

Printed in Scotland for Her Majesty's Stationery Office
by Pickering & Inglis Ltd., Glasgow. Wt.71525 K5

Other Fisheries Publications prepared by the Department of Agriculture and Fisheries for Scotland are shown below.

FRESHWATER AND SALMON FISHERIES RESEARCH

A series dealing with freshwater and salmon research under the above heading.

REPORT ON THE FISHERIES OF SCOTLAND

An Annual Report in narrative form containing the report of the Director of Fisheries Research and dealing generally with Scottish Fisheries, including marine superintendence, salmon fisheries and harbours.

SCOTTISH SEA FISHERIES STATISTICAL TABLES

Annual tables giving full information about the weight and value of fish landed, analysed by species, means of capture and areas of capture.

NON-SERIAL PUBLICATIONS

Lobster Storage, by H. J. Thomas . . . . . Price 1s. 9d. (1s. 11½d.)

Trout in Scotland, by K. A. Pyefinch . . . . . Price 6s. (6s. 6d.)
(A story of brown trout research at Pitlochry).

(Prices in brackets include postage)

Obtainable from Her Majesty's Stationery Office
at the addresses on page 4 of cover or through any bookseller

© *Crown copyright 1965*

Published by
HER MAJESTY'S STATIONERY OFFICE

To be purchased from
13A Castle Street, Edinburgh 2
York House, Kingsway, London W.C.2
423 Oxford Street, London W.1
109 St. Mary Street, Cardiff
39 King Street, Manchester 2
50 Fairfax Street, Bristol 1
35 Smallbrook, Ringway, Birmingham 5
80 Chichester Street, Belfast 1
or through any bookseller

S.O. Code No. 49-384-1-65